

## **RUP Certification via CRM Certification Process: Development of Software with Zero Defect Rate**

Muhammad Javed, Bashir Ahmad, Muhammad Ahmad Jan, Muhammad Ali Abid  
and Muhammad Ali Shah

*Institute of Computing and Information Technology Gomal University,  
K. P. K, D. I. Khan, Pakistan*

*javed\_gomal@yahoo.com , bashahmad@gmail.com, mr\_ahmadjan@yahoo.com  
abid.gu@gmail.com, mohd5\_ali14@yahoo.com*

### **Abstract**

*RUP is based on UP and OOP methodology in order to develop an application whose scope spans to enterprise level but it is labeled as a immature and disorganize development as it involves rework, provided any shortcomings are found in the accomplished phases. Moreover it is observed that risk identification and resolution is not properly handled in RUP as its analysis has no roots towards mathematical framework and no statistical grounds for correctness and reliability. The RUCM, Rational Unified Cleanroom Model- The proposed model, comprises of best practices and principles both of CRM and RUP. Mathematical framework, Mathematical modeling, quantification, statistical test, certification process are the implemented best practices which ultimately leads towards the complete customer satisfaction and a defect rate of zero percentage.*

**Keywords:** *RUP (Rational Unified Process Model, Rework, RUCM (Rational Unified Cleanroom), Zero defect rat*

### **1. Introduction**

Only the two phases of RUP Inception phase and Elaboration phase can be mapped with Cleanroom methodology whereas Construction phase and Transition Phase play the same role for development as in Cleanroom methodology. For first phase of RUP, the Use cases can be mapped with Box structure of Cleanroom methodology and for second phase of RUP, Analysis can be mapped with Correctness process of Cleanroom methodology [1].

In Cleanroom methodology box structure is used for defining the behavior of system and it is used to collect the system requirements. In Cleanroom methodology refinement process for requirements specification is also performed by box structure.

On the other hand in RUP use cases are used to confine the requirements of the system. The behavior of the entire system in RUP can also be expressed by means of use cases. In Cleanroom methodology each and every activity is verified means of validation process i.e. all the defects are removed from an activity, 100 % customer's needs are satisfied and no further iteration is required for the refinement process of that activity.

On the other hand in RUP there is no verification and validation process is found to check the reliability and efficiency of an activity. When the required expectations are not achieved then there is a need of rework for that activity which is the major drawback of this process, so there is a need to map the verification process of Cleanroom methodology to RUP.

Cleanroom methodology has 100 % levels of certification of a process completion. When 100% customer's needs are satisfied then acceptance certificate is to be issued for the completion of an activity process.

On the other hand in RUP, when the activity is completed in any iteration then certificate is not to be issued, due to this major flaw reworking process is performed for that activity when the desired expectations are not meet. In Cleanroom methodology there is no reworking process, because each and every activity is completed with proper certification process. So this feature of Cleanroom methodology should be map with RUP.

## 2. RUP

It was Philippe Kruchten, Ivar Jacobson and few others who conceptualized the RUP as a process harmonized to UML. Rational Software Corporation provides the RUP as the process product for execution of the projects along with its standards, guidelines and templates [2]. RUP can be viewed using both the static and dynamic aspects. Static aspect of RUP involves Role, Activity, Workflow and Artifacts where as dynamic aspects involve various phases and their iterations. RUP comprises of four phases as shown in Figure 1.

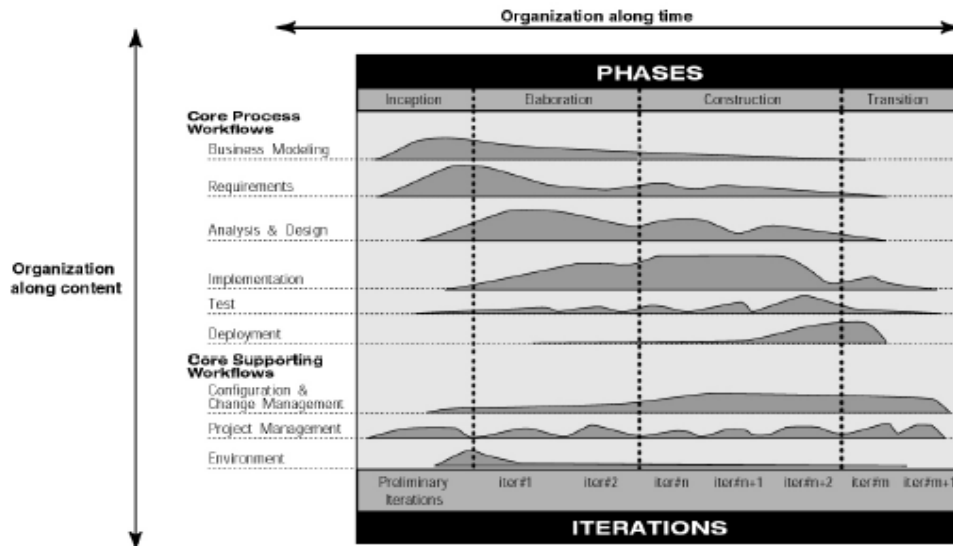


Figure 1. Overview of RUP Model

### 2.1 Inception Phase

The paramount intention of the Inception phase is the involvement of all stakeholders in the objectives of the project. The major artifacts of Inception phase are

- An initial use-case model (10% or 20% complete) when dealing with an initial development cycle
- A domain model which is more sophisticated than a glossary
- A business model , One or several prototypes
- A preliminary development case description.

A landmark or milestone is established which is "life cycle objective". The appraisal criteria of Inception phase encompasses Stakeholder agreement on scope characterization and cost and on schedule approximations, Requirements consideration, trustworthiness of the expenditure and plan estimates, prioritize risks and development process, and Depth and breadth of any architectural prototype.

## **2.2 Elaboration Phase**

It is considered as the most critical of all the phases of RUP. Its main objective is to scrutinize the problem realm, set up a sound architectural groundwork, widen the project plan and eradicate various risks and threats to project. The various conclusions of the elaboration phase are

- A use case model which includes all possible use cases
- List of accompanying obligations responsible for non functional requirements
- Explanation of software architecture
- An executable architecture prototype
- A improved list of risks
- A comprehensive project plan
- An modernized development case that identified the process to be used
- A preliminary user instruction manual

## **2.3 Construction Phase**

In this phase, all residual machinery and functions are industrialized and interacted into the product plus all the features are debugged. The construction phase is carried out in parallel if the project is large enough. The outcomes of construction phase are

- Fully tested and reliable product incorporated and integrated on platform
- Comprehensive instruction manuals
- Details of current release

## **2.4 Transition Phase**

Transition phase is the handing over the product in the user control. Delivery of the product does not ends the responsibility of the development team rather the development team continues to work on the maintenance and keep on producing new releases till the stability is achieved.

The essential activities of the transition phase are

- Deployment of the product

- Optimizing and tuning the processes along with bug fixing, if any
- Evaluating the deployment requirements according to available circumstances

RUP is considered as one of mature software development standards and is applicable to versatile projects. The best practices of RUP are Development of software in iterations, Requirement management, Architecture and use of components, visually modeling the software like prototyping, Controlling and Managing requirements and constantly evaluating the quality of end product [10].

### 3. Cleanroom Software Development Methodology

Dr.Harlan Mills along with his a number of colleagues are considered as the pioneer of the Cleanroom process. The main intent of this process is to make the final deliverable completely error free as this itself is the standard of a low cost product [4]. This process of making error free product yields an output of highest quality and at the same time critical for decision making. The Cleanroom process is an end to end disciplined approach for software development which involves all the stages like planning, designing, testing. At the end of a successful development increment, a certificate is issued which certifies that the increment is completely error free and is at zero defects rate, confirming there will be no need of rework [3].

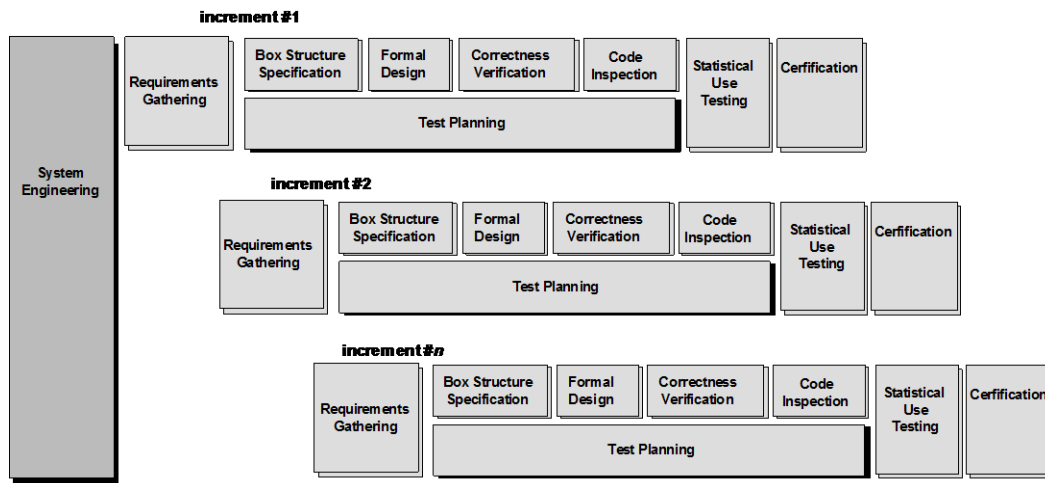


Figure 2. Cleanroom Certification Process Model

#### 3.1 Requirement Gathering

Requirements gathering phase involve all comprehensive details of the requirements of the customer which will be analyzed and designed in each increment.

#### 3.2 Box Structure Specification

Box structure involves the separation and isolation of behavior, data and procedures defined in the functional specification phase.

### **3.3 Formal Design**

Various specifications, also known as “black boxes”, keep on being refined and polished in every upcoming increment so that they become equivalent to the architectural and procedural designs, which are also known as “state boxes” and “clear boxes,” correspondingly [5].

### **3.4 Correctness Verification**

The correctness verification is carried out starting from the box structure which is at the highest level and then progressing towards the detailed design and coding by means of “correctness questions”. If by any chance these practices do not certify the correctness of the specifications, then as a result of this more ceremonial mathematical routines are used for authentication.

### **3.5 Code Generation, Inspection and Verification**

The box structure specifications which are symbolized using their appropriate languages are transformed into suitable programming languages.

### **3.6 Statistical Test Planning**

It involves the planning and designing of a series of test cases which put into effect the “probability distribution”.

### **3.7 Statistical Usage Testing**

The Statistical Usage Testing accomplishes a set of tests which are originated from a statistical sample possible program by all users. It involves the creation of test cases, their respective execution and collection of error data [6].

### **3.8. Certification**

As all the verification, inspection and usage testing is successfully accomplished plus all possible and potential errors are corrected, then the increment is given a clearance certificate which guarantees that it can be integrated easily.

## **4. Mapping of CRM into RUP**

RUP consists of four phases .Each activity in every phase of RUP can be completed in number of iterations and after the completion of each iteration there is a need to issue a certificate to carry on work successfully and verified by the customer needs via this certificate. The next iteration can never be started until or unless if the acceptance certificate is not to be issued to the previous iteration. The acceptance certificate will be issued only on these conditions, there should be no existence of defect rate, the correctness and verification is to be performed by statistical test and customer needs must be satisfied if any one condition is not to be satisfied then the acceptance certificate can never be issued for the completeness of that activity.

#### 4.1 Overview of Mapping of Major Features of CRM and RUP for Box Structure and Use Case

By incorporating all the best features of CRM into RUP, the overall documentation, quality, efficiency and performance is to be increased up to the highest level of satisfaction and the time for development is also decreases through proposed model named as RUCM (Rational Unified Cleanroom Model).

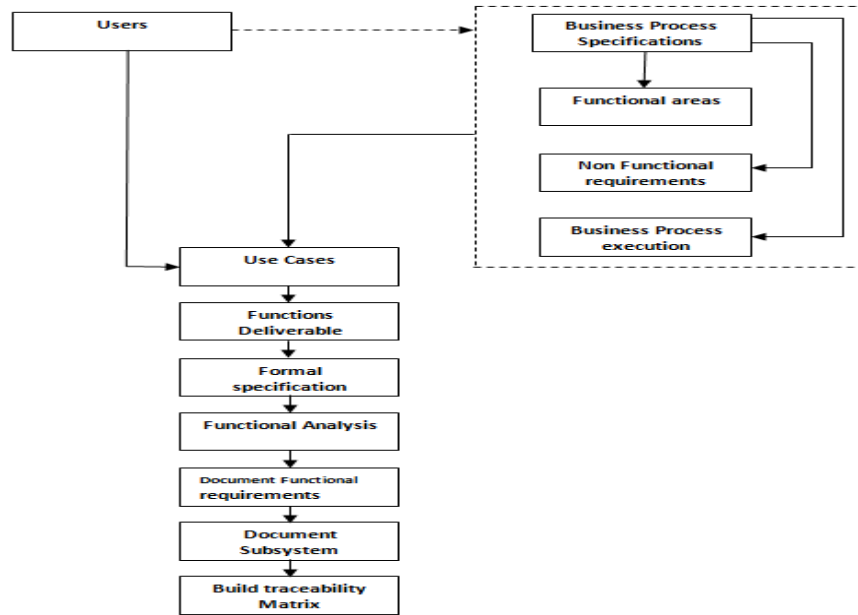
**Table 1. Overall Mapping Features of Cleanroom Methodology and RUP Box Structure and Use Case**

S.NO	Behavior Specification (Features)
1	Business Process Execution
2	Formal specification
3	Functional Analysis
	State Free (features)
4	Fault-free
5	Behavior of stimuli and responses
6	Sequence based specification
	Data encapsulation(Features)
8	Data transition
9	Storage of stimuli in State variables
	Procedural services(Features)
10	Procedural abstraction
11	Procedural control
12	Analysis procedure
13	Static analysis
14	Quantitative analysis
	Systematic frame work(Features)
15	Systematic structuring of Product
16	Mathematical framework
17	Systematic software testing
	Increment Design(Features)
18	Increment planning
19	Increment certification
20	Requirements Gathering
21	Functional Increments
	Full scale development(Features)
22	Reengineering activity

#### 5. RUCM

RUCM comprises of two additional phases which are not available in RUP. These phases are System perception phase and planning phase, and number of changes has been made in elaboration phase of RUP by adopting the best features of Cleanroom methodology to increase the documentation regarding quality, efficiency and performance. The effort required for the completion of project is also decreased.

According to Author's proposed model When the features of Cleanroom software engineering are incorporated into RUP in inception phase, the sub phases of RUP i.e. identification of most essential requirements," Mile-wide inch deep" description and the detail key actors and use cases are combined then a new phase is generated named as System perception phase where these three phases are merged. The logical flow of these steps with a new sequence for System perception phase in proposed model as shown in Figure 3.



**Figure 3. System Perception Phase**

## 6. Certification process for System Perception phase

The detail certification process for each activity involved in the System Perception phase is as under:

### 6.1 Certification of User

For the issuance of user's certificate it is to ensure that all the actors have been properly identified and their roles are well understood.

Table 2 illustrate that during the first iteration objectives of the user specification have been achieved to fulfill the customer needs therefore certificate has been issued in first iteration.

### 6.2 Certification of Business Process Specification

For the issuance of Business process specification' certificate, when all the required business processes are covered by business process specification then certificate will be issued. For this activity the statistical test can be applied between customer needs and leading of defects. When the results are to be achieved after verifying these fields Customer's need, zero defect rate, statistical test then acceptance certificate will be issued. In Table 2 results are not achieved according to the required customer's expectations in iteration-1 (I-1) because customer's needs are not satisfied and defect rate is also exist and statistical test is not verified so certificate is not issue for the completion of this activity, so the iteration-2 (I-2) is required to refine the Business process Specifications .In this iteration customer needs are satisfied but the defect rate is also exist and the statistical cannot be verified so certificate is not to be issued for this iteration , there is a need of iteration-3 (I-3). In iteration-3 the customer needs are satisfied but defect rate is still exist and the statistical test can not verify this activity so certificate is not to be issued , so there is a need of iteration-4 (I-4). In this

iteration the activity is completed , because customer's needs are satisfied , and defect rate is not exist , the statistical test is also verified , so the acceptance certificate is to be issued for the completion of this activity as illustrated in Table 2.

The same analogy will be applied to all the activities in Table 2.

### **6.3 Certification of Functional Areas**

For the functional Areas activity customer needs must be 100 % satisfied , because this activity is completed by programming and if any defect is found in functional area then required results cannot be achieved for a specific function , this activity is also completed in iteration-4 as shown in Table 2 where customer needs are satisfied , and defect rate is not exist , the statistical test is also verified , so the acceptance certificate is to be issued for the completion of this activity.

### **6.4 Certification of Non-Functional Requirement**

It is not easy process that the non-functional requirements are added in system at the end. The non-functional requirements should be included throughout the development process.

Table 2 illustrates that during the first iteration all customer's needs are to be satisfied, so the acceptance certificate is to be issued for the completion of this activity.

### **6.5 Certification of Business Process Execution**

For the issuance of Business process execution's certificate it is to ensure that all the basic plans and normal the iteration-4 this activity is completed, where all the customer's needs are needs are cause of actions and standards provided to execute the business process.

Table 2 illustrates that during to be satisfied and no defect exist and statistical test is also verified, the acceptance certificate is to be issued for the completion of this activity.

### **6.6 Certification of Use Cases**

Use cases are used in system analysis to identify, clarify, and organize system requirements. The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goals, if all the functional requirements are organized and customer's needs are fulfill and having no defect in System requirements and statistical test is also verified then certificate is to be issued for the completion of this activity. This activity is completed in iteration-2 as illustrated in Table 2.

### **6.7 Certification of Functions Deliverables**

For function deliverable activity, the objective of statistical test over function test is to measure the quality of the functional (business) components of the system whether the function is deliverable or not if the function is ready to deliver for any system and fulfill all the needs of customer then certificate will be issue and if the function deliverable not fulfill all the customer's needs then next iteration is to be required to clarify function deliverables. This activity is completed in iteration-4 where customer needs are satisfied and defect are not



exist, statistical test is also verified so the acceptance certificate is to be issued for the completion of this activity as illustrated in Table 2.

### **6.8 Certification of Formal Specifications**

For the certification of formal specification activity, when requirement specifications to be clarified, precision and accuracy is to be improved in requirement specification then certificate is to be issued. This activity is completed in iteration-4 where the customer's needs are to be satisfied and no errors are defects are to be found and statistical test is also be verified so the acceptance certificate is to be issued for the completion of this activity as illustrated in Table 2.

### **6.9 Certification of Functional Analysis**

For the issuance of certificate for Functional analysis, when required tasks for processing are refined for desired functions then certificate will be issued. This activity is completed in iteration-2 Functional where all the customer's needs are to be satisfied and defect are not exist, statistical test is also verified so the acceptance certificate is to be issued for the completion of this activity as illustrated in Table 2.

### **6.10 Certification of Document Functional Requirements**

For the issuance of certificate to this activity, when all the functional requirements are associated with business requirements and all plans are provided for functional requirements then certificate will be issued. This activity is completed in iteration-1 where all customer's needs are satisfied, so certificate is to be issued for the completion of this activity as illustrated in Table 2.

### **6.11 Certification of Document Subsystem**

For the certification of document subsystem when each subsystem defined the customer's needs then certificate will issued. This activity is completed in iteration-1 where all customer's needs are satisfied, so certificate is to be issued for the completion of this activity as illustrated in Table 2.

### **6.12 Certification of Traceability Matrix**

For the certification of traceability matrix when all the test cases are to be properly mapped to customer's requirements, system specification should be validated and verified and quality of system should also improved against identifying requirements. This activity is completed in iteration-4 where the customer's needs are to be satisfied and no errors are defects are to be found and statistical test is also be verified so the acceptance certificate is to be issued for the completion of this activity as illustrated in Table 2.

**Table 2. Execution of Template for Certification of Perception Phase**

Activity	Customer's Needs	Leads to defect	Statistical test	Certificate	Suggestion
Users	Y			Y	Accepted
Business Process Specifications	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4
	Y	N	Y	Y	Accepted
Functional Areas	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4
	Y	N	Y	Y	Accepted
Non Functional requirements	N			N	1-2
	N			Y	Accepted
Business Process execution	N	Y	N	N	1-2
Business Process execution	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4
	Y	N	Y	Y	Accepted
Use Cases	N	Y	N	N	1-2
	Y	N	Y	Y	Accepted
Functions Deliverable	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4
	Y	N	Y	Y	Accepted
Formal Specification	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4
	Y	N	Y	Y	Accepted
Functional Analysis	N	Y	N	N	1-2
	Y	N	Y	Y	Accepted
Document Functional requirements	N			Y	Accepted
Document Subsystem	Y			Y	Accepted
Build traceability Matrix	N	Y	N	N	1-2
	Y	N	N	N	1-3
	N	Y	N	N	1-4

## 7. Conclusion

It has been observed by adopting the best features of Cleanroom methodology to increase the documentation regarding quality, efficiency and performance. The effort required for the completion of project is also decreased. The RUCM is all about focusing on software development with the involvement of all stakeholders at greatest possible level and this yields improved process quality. Certifying each increment guarantees the improved process quality and that is what lies at the heart of RUCM. As far as quality of each increment is considered in RUP, each increment is not thought as the mature one but at the same time RUCM carries the opposite properties to that of RUP in this regard.

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